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PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

LESSONS LEARNED DURING OT II
TESTING OF THE AN/TPQ-36 RADAR

STUDY PROJECT REPORT
PMC 77-2

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FORT BELVOIR, VIRGINIA 22060

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE: LESSONS LEARNED DURING OT II TESTING OF THE AN/TPQ-36 RADAR

STUDY PROJECT GOALS: To pass on lessons learned in the OT II testing of the AN/TPQ-36 radar.

STUDY REPORT ABSTRACT:

This report highlights some of the problems that occured in the OT II testing of the AN/TPQ 36 radar. The observations are those of the author and include problems both unique and general. The report is summarized by a check point list of areas for concern for a Program Manager in preparation for OT II testing.

SUBJECT DESCRIPTORS:

USER TESTING	10.10.02.00
OPERATIONAL TESTING	10.08.03.00
OT II TESTING	

NAME, RANK, SERVICE	CLASS	DATE
ROBERT K. DUBOIS, GS-13 USA	PMC 77-2	November 1977

LESSONS LEARNED DURING OT II TESTING OF THE AN/TPQ-36 RADAR

Individual Study Program

Study Project Report

Prepared as a Formal Report

Defense Systems Management College

Program Management Course

Class 77-2

by

Robert K. DuBois
GS-13 USA

November 1977

Study Project Advisor
Col. Robert E. Lucas, USAF

EXECUTIVE SUMMARY

The goal of this paper is to assist the Army Program Manager and/or other interested persons in becoming familiar with problems that occur prior to and during OT II testing. The views expressed in this paper are those of the author, based on experience, and may not necessarily reflect the views of the AN/TPQ-36 Program Manager or the Army. This paper points out many problems that occured during the OT II testing of the AN/TPQ-36 radar. Some of the problems discussed are unique to this program and some apply to programs in general. Some problem areas discussed are planning, training, support equipment manuals and data. The report is summarized by a fifteen point check list of general areas of concern for a Program Manager during the time period of OT II testing.

TABLE OF CONTENTS

SECTION I

INTRODUCTION

<u>Purpose</u>

A lessons learned paper is not a historical accounting of events, but rather a systematic approach of going from the specific study to the general rule. The specific, in this case, is the user testing of the AN/TPQ-36 radar. What I would like to do in general is develop a check list of areas of concern for any Program Manager during the time frame of OT II testing.

Operational Testing is a key milestone in the acquisition process. This test is normally the first time man, machine and logistics play together in a real world scenario. Direct responsibility for the user testing lies in the hands of the Independent Evaluator. The test is conducted for the Office of the Secretary of Defense to assist the Defense Systems Acquisition Review Council (DSARC) in making a system production decision.[1] The Independent Evaluator in the case of the Army is the Operational Test and Evaluation Agency. They are also a non voting member of the DSARC.

Even though OTEA has primary responsibility for running the user test, the Program Manager still has many duties. The Program Manager who thinks he can turn his system over to the Independent Evaluator and walk away, is doing his program and his system an injustice.

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[1]The AN/TPQ-36 is a DSARC level program but the Secretary of Defense has allowed it to remain at the ASARC level of approval. Therefore, the OT II test report will be part of an ASARC decision for production.

System Description

The AN/TPQ-36 radar is a highly mobile phased array radar for tracking and locating mortar and artillery fire. It possesses the unique ability to follow a terrain crest (See figure 1). The radar beams are set at the crest of the surrounding hills, and as the radar scans over a 90 degree sector, the beams follow a contour of the terrain. When a projectile pierces this fence, a pencil beam is scheduled to intermittently track the projectile through 5 degrees in elevation. From these plot points of the trajectory, it extroplates a grid location back at the origin. The weapon, once located, is displayed in the control shelter. The display is exhibited by a lighted grid coordinate on a map, a digital read out, and a hard copy print out.

The AN/TPQ-36 radar was developed by Hughes Aircraft Ground Systems Group in Fullerton, California. It was developed on a sole source cost plus incentive fee type contract. The radar was originally designed as a mortar locating radar, but changes in the "Threat" compelled adding an artillery locating capability.[2] The Marine Corp. was developing a hostile weapons locating system during the same time period under a contract with Raytheon Corp. This necessitated a comparitive evaluation or shoot off at Yuma, Arizona during the development phase. The AN/TPQ-36 proved to be superior to the Marine Corp. system and consequently the Corp.

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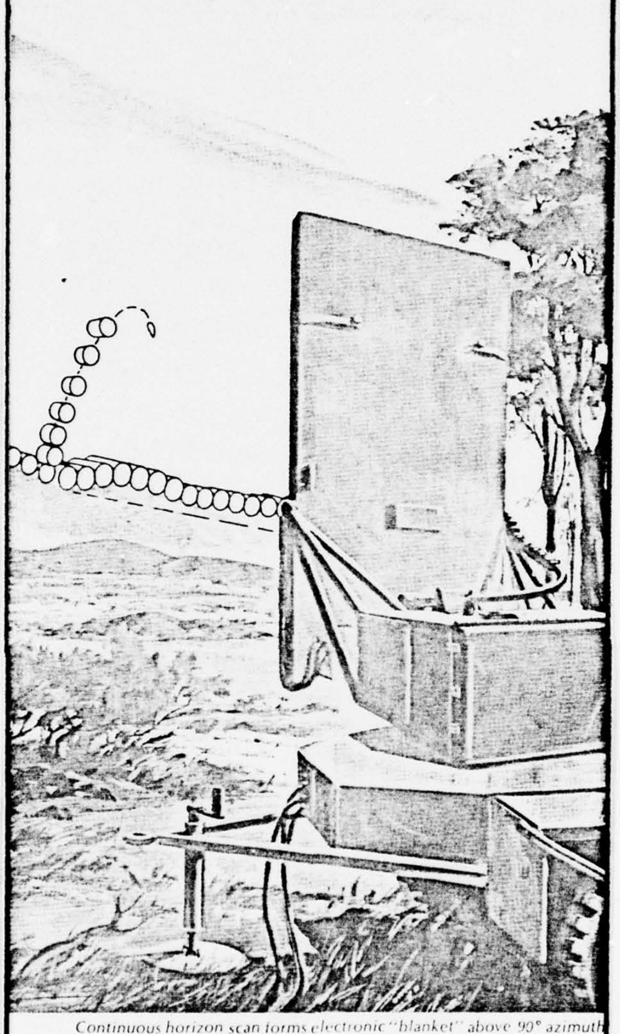
[2]For comprehensive discription of the system, see the OT II Test Plan System Description and the Hughes Aircraft brochure appendices B and C.

will make a joint procurement with the Army in production.

AUTOMATED RESPONSE TO MORTAR FIRING



Continuous horizon scan forms electronic "blanket" above 90° azimuth sector to detect and automatically initiate tracking of mortar rounds

- Azimuth scan just above the horizon establishes an electronic screen over nearby enemy positions. Mortar firings are detected as they pass through the sensitive high-data-rate surveillance screen.
- The computer instantly directs the radar to point a verification beam at each target, then automatically initiates track.
- Filters in the signal and data processors reject returns from ground, weather, birds, insects and distant aircraft.
- While continuing the search program and tracking all verified targets, the computer "back tracks" each shell trajectory to its origin. Location data is displayed for the operator who transmits the target map coordinates to the artillery for effective counterfire.

Figure 1

SECTION II

PRE OT II TESTING

PLANNING

Operational testing of the AN/TPQ-36 radar requires many artillary and mortar pieces firing in concert. This necessitates that the test be run where there is Divisional support. The original test was scheduled for Ft. Riley, Kansas. Due to training requirements, there was a limited amount of time in which Ft. Riley could participate in the test. During a reliability road test prior to OT II testing, the designated test model was overturned. This accident inevitably dictated a two month slip in the program. Consequently, OTEA had to hastily put together a plan to support the test in Korea. This presented some major problems for the Program Manager in the area of logistics and contractor support. OTEA had problems of their own in that the radar sites were located very close to the Demilitarized Zone, and the impact area for artillary was only one kilometer square. Since the radar sites were in such close proximity of the Demilitarized Zone, the jamming and counter measures portion of the test could not be accomplished in Korea. Therefore, a separate jamming and counter measures test was set up at the Marine Corp. base at 29 Palms, California. There were other problems beyond the control of OTEA, one being the rumored withdrawal of United States troops from Korea. It was finally evident, two weeks before shipment, that the security and political problems of running the test in Korea were insurmountable. At

this time a third and final plan was set up to run the test at Ft. Carson, Colorado. The final schedule ended with the major test at Ft. Carson, Colorado and the jamming and counter measures test still at 29 Palms, California.

The Program Manager has many inputs to the OT II test site location, primarily through the Test Integration Working Group (TIWG).[3] This brings us to the first check point on the Program Managers check list.

Check Point One: The Program Manager should develop as many contingency plans for OT II as economically possible. These contingency plans should be developed at the same time as the test design plan and should include all support agreements.

Training

The Program Manager is the undisputed advocate of his system. If this enthusiasm is not unfounded, the Program Manager should welcome pre OT II training as an opportunity to develop evangelists for his system. The Program Managers office has the obligation to train all the participants in the OT II test. Training for the AN/TPQ-36 program included operational personnel, maintenance personnel and monitors. One of the key Points to consider in selecting people for these jobs is their termination date of service. The people selected should have termination

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[3]The TIWG is a chartered group which includes represenatives from the Program Managers office, contractor, user, and operational and development testers. Their function is ostensibly to review all testing and eliminate duplications.

dates that are well past the lates conceivable date for completion of the test. This will eliminate problems of motivation that could bias the data in the test. The training should be set up in such a way that it terminates just prior to the beginning of the test to insure that the training is current. A real problem occures when the test is delayed. In the case of the AN/TPQ-36, delays necessitated a refresher course be set up prior to the test. One observation made in the training for the AN/TPQ-36 was that the contractor in his training program, had not required the students to do the maintenance test set ups. During the test, this became a problem when the maintenance personnel had difficulty selecting the appropriate test equipment. This problem was compounded by the fact that in some cases the contractor had used commercial test equipment. To the plant engineers doing the training, there was not a significant difference between commercial and government test equipment, but to the maintenance people trained on only one piece of equipment the differences were monumental. An observation to come out of the OT II test is that the user should have had a trained member on the test team. The user in the Army is the Training and Doctrine Command (TRADOC). TRADOC sets the doctrine for use of the equipment. OTEA uses this doctrine in the design of the OT II Test Plan. Since all of the unforseen situations cannot be treated in the test plan, a well trained represenative of the user, with the authority to establish doctrine as required, must be present throughout the test. This therefore adds four more check points

to the Problem Managers check list.

Check Point Two: <u>Select nominees for training that will be continuing in the service after OT II testing.</u>

Check Point Three: <u>Training should contain a high percentage of hands on experience and should be completed just prior to the start of the OT II test.</u>

Check Point Four: <u>Press for the maximum number of pre OT II training slots as economically possible.</u>

Check Point Five: <u>Include the user as part of the training program.</u>

<u>Spares and Test Equipment</u>

The one most common problem with spares and test equipment is inventory. The Program Manager and OTEA should resolve their differences on what equipment is to be supplied for the test, long before the test begins. The test site is not the place to argue over what should be on the list. All that should be required at the test site is an inventory of parts shipped. This inventory was the first time I, personally, had seen all the special test equipment together in one place. Since I have done most of the common direct, general and organizational maintenance test set-ups, it surprised me to see many pieces of test equipment I had never used before. A fast survey of the direct support maintenance manuals showed that approximately 60 percent of the major items of test equipment were required for only about 15 percent of the direct support tasks. This makes one suspect that a high rate of return on life cycle costs could be gained

by investigating this area.

The Department of Defense Directive 5000.3, states that one of the purposes of OT II testing is to demonstrate that the system can be supported logistically in the deployed status. The Program Manager's dilemma is in simulating his logistics philosophy when the entire logistics system is not complete. The AN/TPQ-36 program required the contractor to simulate the depot maintenance. It is very desirable in OT II testing to have the contractor take a very low profile. This is because any interface between the contractor and OTEA this late in the game can only make evaluators question whether Army troops could actually maintain the system. I would suggest that if the contractor is to be used at the test site, that he be isolated from the OTEA personnel. The contractors interface should be through the Program Manager's representative.

In the area of direct support, several questions arise. Will the direct support maintenance man stay in the field with the system? If so, how will he transport the test equipment so that it is not damaged? I bring this up because in the OT II test, the direct support man was required to stay in the field during the entire test. This was done to minimize the "down time" during a direct support failure. He was given an expanding van without racks to protect the test equipment and was required to live in the van which lead to much of the equipment being damaged and misplaced. This also leads to a morale problem when the direct support man is called on to do his job. The

final question is, what did OTEA plan to do if they did not get enough failures to evaluate the logistics support system? On the AN/TPQ-36 test, OTEA decided to simulate failures. This should be permissible if simulated failures are planned well in advance so that they will not damage the system. They also must be selected to demonstrate the correct symptoms when the failure occurs. It was obvious that OTEA had not used forethought in this area. This testing of simulated failures displeased the Program Manager's office because OTEA had been invited to participate in the earlier Maintenance Demonstrations at the contractors plant and had declined. This brings us back to the Program Manager's check point list.

Check Point Six: <u>Have an agreed upon inventory check list for spares and test equipment.</u>

Check Point Seven: <u>If the contractor is involved in the test, have him answer to the Program Manager and retain a low profile.</u>

Check Point Eight: <u>Insist that OTEA observe all Maintenance Demonstrations prior to OT II testing.</u>

Manuals

There will never be a manual that satisfies everyone. Students during training are one of the best inputs for correcting manuals. As I mentioned earlier, it is very desirable in any test program, to have all of the training current. With very little time between training and start of test, getting the manuals updated is a problem. Since many changes will also be suggested during OT II, I find nothing wrong with working from

marked up manuals. The manuals should be formally updated after completion of OT II test.

Check Point Nine: <u>Don't be reluctant to use marked up manuals during OT II testing.</u>

SECTION III

TEST

<u>The Warm Up Period</u>

The Program Managers represenative and the contractor should try to arrive early for the OT II test. A formal date should be agreed upon for making the necessary transition. The contractor should thoroughly review his system, insuring that no problems exist. The system should then be operated as much as possible before systems turn over. This warm up period is crucial for good testing. This should be accomplished even if it causes some delay in the test. Many times, because of the large number of resources required in testing, we let the test schedule take priority over more important factors. This can often adversely effect the system. In the system check-out of the AN/TPQ-36. it was found that cap screws of incorrect length had been used in a keeper on a roller bearing. The contractor was in a panic mode to turn the system over to OTEA. The engineers in their haste to fix the problem had inadvertently forgotten to tighten a set screw in place on an azimuth encoder. This caused later repercussions, when during the test, one entire firing scenario had to be discarded.

Check Point Ten: <u>Do not allow the pressures of test schedule and resources to obscure the objectives of the test</u>.

Test Management

The test plan should be ratified by all concerned parties before the beginning of OT II. When the Program Managers office reviewed the test plan, it seemed acceptable, but in practice many questions surfaced. OTEA had a section in the test plan to test radar transparent camouflage nets. When the test was actually run, hundreds of firings were done with and without the nets. This testing would have been fine if its purpose was to prove that radar transparent nets are radar transparent. However, the purpose of the test was to show a physical compatibility between the radar and some netting configuration. I feel the firings were a gross waist of money. These firings were very distressing when you realize that some of the key parameters of the radar, that should have been tested were not. In a heavy firing scenerio, the primary goal is to locate as many different firing positions as possible. The theory is that it is better to locate many different gun positions as opposed to locating one gun position many times. The radar accomplishes this by an auto censor capability that is selected by the operator. The radar operator presses a key board and enters the number of targets he wants as an upper threshold. If, for example, the operator selects three, this means that after a certain target has been located three times, the computer will no longer waste time on that target. This gives the radar more time to acquire new targets. It was always assumed by the Project Manager that the use of this option would be at the discretion of the operator.

As I mentioned earlier, TRADOC establishes the doctrine for the OT II test plan. TRADOC had omitted any guidance on the use of auto censoring. TRADOC and OTEA could not resolve their differences and, with the schedule pressing, it was decided the operator could not use the option.[4] This brings us back to one of the first points I mentioned. TRADOC should have a trained man at the site with the suthority to establish doctrine.

The AN/TPQ-36 has two modes of operation. One mode is when a small window is set up out in space and an artillery shell is fired through it. The radar tracks the shell and gives grid locations on the impact. This is called the friendly fire mode. It is used to register friendly fired weapons. The normal mode of operation is where the radar scans a 90 degree sector, tracking the incomming projectiles and determining their point of origin. This is the hostile fire mode. Throughout the OT II test plan, OTEA had referred to the friendly fire test as friendly fire with hostile clutter. When talking about radars, clutter normally means radar returns from natural objects such as trees, rocks, and clouds. What OTEA meant by hostile clutter was, that during friendly fire missions, they would try to put a hostile shot in the registration window at the same time. Although the Program Manager realized that this test could have some academic value, he felt that because of the small registration window, it

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[4]The Program Manager had hoped that empirical data could be gathered in this test to aid the operator in selecting the upper threshold.

was statistically very unlikely to occur. When the two artillery trajectories were laid out, we found that the impacts for both trajectories were one and the same. The Program Managers office pointed out that they could not think of a war scenario were friend and foe fire at the same target at the same time. OTEA dropped the hostile clutter from the test. This brings us to our next check point.

Check Point Eleven: <u>The Program Manager should religiously compare the OT II test plan to the validated threat.</u>

Data

When the AN/TPQ-36 was going through the first development test, the Program Managers office set up data sheets for the data collectors to use. The data sheets were staffed through the functional groups at the Electronics Command. The functional groups were asked to add to the data sheets if they needed more information. During the first field test, data collectors had to fill out eight sheets of data for each shot. This was totally unacceptable and in successive tests, we reduced the data sheets to two. In reducing the number of documents, we had put the data in a more usable form without sacrificing any usable statistics. The contractor had also developed an automated data reduction system which gave the program office a very fast turn around time. This data reduction facility was offered to OTEA for the operational test, but unfortunately they declined to use it. OTEA

went through a learning curve of their own. There was a point in time when even the OTEA evaluators could not understand the data. The Test Integration Working Group should strive to get all test data consistant. This makes the data easier to evaluate and aggregate.

Check Point Twelve: <u>The test data collection documents should be as compatible as possible throughout all the tests in the life cycle of the system.</u>

Reliability, Availability, and Maintainability (RAM) data was the biggest deterrent in the entire OT II test. Raw data on RAM are collected on what OTEA calls Operational Test Incident Reports (OTIR's). This RAM data is collected by data collectors that go through the same training as the direct support maintenance personnel. As failures occured or maintenance was performed, these OTIR's were filled out to reflect the facts and time. The OTIR'S are then held until after OT II is complete. A RAM scoring conference is then held and the OTIR's are scored against the TRADOC failure criteria (see appendix D). The scoring conference determines if the failures were operator error, system failure, system abuse or not a chargeable failure. After the scoring conference the Mean Time To Repair (MTTR), the Mean Time Between Failures (MTBF) and Availability of the system can be determined. What I have described to you is the way the system is suppose to work. The way the system actually worked, was that the data collector was speculating on the cause of the fail-

ures. The data sheets not only contained the facts, but propaganda to defend OTEA's position that incidents were in fact failures. The OTEA test director sent the OTIR's back to the data collectors for elaboration sometimes four or five times. This caused a lot of extraneous and erroneous data to be included in the OTIR's. The scoring conference consists of OTEA, the Program Manager and TRADOC with OTEA being the chairman. OTEA and the Program Manager have one vote each and TRADOC two votes. OTEA goes to the scoring conference with the attitude that all OTIR's are failures. The scoring conference boils down to TRADOC deciding which are failures and which are not. OTEA has the upper hand in this game because they have tailored the OTIR's to their position. The only way I can see to eliminate these problems is for the Program Manager to get copies of the original OTIR's and review them to be certain that only facts and times are recorded.

Check Point Thirteen: All data recorders should be instructed to report facts and not personal analysis.

The RAM data as it was collected at Ft. Carson was posted on a large chart in the office. This chart contained interum calculations for MTTR, MTBF, and Availability. These calculations were all made using raw unscored data that did not reflect the true accomplishments of the system. The chart was used to brief many visitors and many people used the figures to make their weekly reports. The Program Managers Office condemned this prac-

tice on many occasions, but to no avail. The Program Manager had no idea where this information had be distributed and consequently spent many hours on the phone correcting the erronious numbers.

Check Point Fourteen: <u>Do not allow data to be distributed until it is validated.</u>

The OTEA field test team runs the operational test, but they are not the evaluators of the test data. I strongly feel the people evaluating the test must intimately know the circumstances under which the data was taken.

Check Point Fifteen: <u>All the evaluators of the test data should be present throughout the running of the test.</u>

SECTION IV

SUMMARY

The Program Managers optimistic view of his system is more than balanced by OTEA's pessimistic view. This paper may help the new Program Manager understand this relationship and plan for some of the stumbling blocks. I hope this check list will serve as a useful tool to new Program Managers.

Program Managers OT II Check List

Planning

1. The Program Manager should develop as many contingency plans for OT II as economically possible. These contingency plans should be developed at the same time as the test design plan and should include all support agreements.

Training

2. Select nominees for training that will be continuing in the service after OT II testing.

3. Training should contain a high percentage of hands on experience and should be completed just prior to the start of the OT II test.

4. Press for the maximum number of pre OT II training slots as economically possible.

5. Include the user as part of the training program.

Spares & Test Equipment

6. Have an agreed upon inventory check list for spares and test equipment.

7. If the contractor is involved in the test, have him answer to the Program Manager and retain a low profile.

8. Insist that OTEA observe all Maintenance Demonstrations prior to OT II testing.

Manuals

9. Don't be reluctant to use marked up manuals during OT II testing.

Warm Up Period

10. Do not allow the pressures of test schedule and resources to obscure the objectives of the test.

Test Management

11. The Program Manager should religiously compare the Ot II test plan to the validated threat.

Data

12.. The test data collection documents should be as compatble as possible throughout all the test in the life cycle of the system.

13. All data recorders should be instructed to report facts and not personal analysis.

14. Do not allow data to be distributed until it is validated.

15. All the evaluators of the test data should be present throughout the running of the test.

APPENDIX A - Definitions

ASARC - Army System Acquisition Review Council.

DSARC - Defense System Acquisition Review Council.

MTBF - Mean Time Between Failures.

MTTR - Mean Time To Repair.

OT - Operational Test.

OTEA - Operational Test and Evaluation Agency.

OTIR - Operational Test Incident Report.

RAM - Reliability, Availability and Maintainability.

TRADOC - Training and Doctrine Command.

APPENDIC B

1.0 GENERAL.

1.1 Description of the system.

a. The radar set AN/TPQ-36 is designed to detect mortar and artillery firings, automatically calculate both origin and point of impact, and designate the hostile weapon location accurately for countermortar and counterbattery fire.

b. The AN/TPQ-36 is a highly mobile radar for automatically locating hostile mortar, cannon artillery, and short-range rockets. An automatic system provides the capability to locate weapons firing simultaneously from multiple positions. In addition, the radar can be used to register and adjust friendly mortar and artillery fire.

c. Using a combination of radar techniques and computer controlled signal processing, the radar detects, verifies, and tracks projectiles in flight, extrapolating the track data points to the location of the firing position. When the location has been corrected for altitude, it can be automatically transmitted to TACFIRE by the operator.

d. The radar consists of an S-250 shelter carried on an M-561 Gama Goat which pulls the antenna trailer assembly. The trailer assembly includes the antenna and associated electronics, the transmitter, and a major portion of the receiver. The S-250 shelter provides space for the operation of the radar and includes the data processing hardware. Power for the system is provided by a 10-kilowatt, 400-Hertz generator which is carried on the antenna trailer. The shelter and the antenna trailer can be transported by helicopter.

e. ~~Software~~ Modifications to the AN/TPQ-36 have optimized it ~~permit optimization~~ for location of artillery as well as mortars, however, the radar will primarily be used as a mortar locating radar. The AN/TPQ-36 will be organic to the target acquisition battery assigned to each division, and the direct support battalion of each separate brigade. The division's AN/TPQ-36's will be allocated by the division artillery tactical operations center (TOC) across the front. The using artillery battalion will site and operate the radar as its own. The radar will be positioned within the division area where it will provide the greatest possible coverage of the supported brigade. The three radar sections will be employed to provide movement and operational alternatives to optimize radar coverage/survivability trade-offs and to provide coverage to the greatest extent possible over the complete division front. The radar section should when feasible, be located near a friendly unit for mutual security purposes. Alternate sites must be selected and coordinated to allow for timely fifth-order survey and communications with the supported unit. Tactical employment will be in accordance with FM 6-121 and 6-161. The electronic warfare (EW) threat will probably preclude electronic preparation of site evaluation charts.

survey ? 4th order

1.2 Purpose of test. To provide data and associated analyses regarding the operational effectiveness and military utility of the radar set, AN/TPQ-36 System to the Development Acceptance In-Process Review (DEVA IPR).

DARCOM/TRADOC 9 September 1976

FAILURE DEFINITION AND SCORING CRITERIA
FOR THE AN/TPQ-36 MORTAR LOCATING RADAR (MLR)

PREFACE

TO BE COMPLETED AT A LATER DATE (By TRADOC)

SECTION I FAILURE DEFINITION

MORTAR LOCATING RADAR FAILURE DEFINITION: For the purpose of assessing mission reliability, a failure is defined as any malfunction which causes inability to commence operations, cessation of operation, or degradation below required levels of performance. In addition, any failure which causes or may cause a critical or catastrophic hazard to personnel or equipment as defined by MIL-STD-882 shall be charged as a reliability failure.

AMPLIFICATION:

a. The following are considered mission reliability failures:

(1) Any mission failure stopping operation, the cause of which cannot be traced to a specific hardware or software failure, which is of short duration (not to exceed 5 minutes) before acceptable operation could resume, will be classified as an intermittent failure, but will not be charged. If the same symptoms occur more than once within 24 mission hours, it will be one chargeable reliability failure and repair will be required. (Note: Due to the fact that Bite development is a continuing process if it can clearly be shown during the scoring conference that an intermittant fault indication is actually a BITE problem which has been corrected it will not be charged as a reliability failure).

(2) Any failure that occurs during the test that does not meet the criteria for non-relevant classification listed in b below. (Note: Relevant failures of GFE will be included in the system reliability but will not be charged against the radar reliability).

b. The following are not considered mission reliability failures:

(1) For simultaneous related malfunctions, only the primary mission stopping malfunction will be charged. Secondary failures will not be charged against reliability. (Secondary failures are defined in MIL-STD-781).

(2) Failures resulting from not following prescribed operational or maintenance procedures or schedules.

(3) Failures resulting from test item abuse, obvious operator or technician errors, or accidents not caused by component failure or design characteristics.

(4) Failures detected during initial inspection (equipment inventory/ inspection prior to test initiation.)

(5) A failure that reoccurs as a result of an ineffective repair of a previously charged failure will not be charged against reliability since it was an improper maintenance action and not a reliability problem.

(6) Failures of incidental items, i.e. light bulbs or LED's which are missing up to 3 dots.

(7) Scheduled replacement of parts/components before failure or failures of limited life items after their life period, shall not be charged. This applies only to parts/components listed prior to failure occurrence in a contractor furnished, government approved limited life item list, e.g. TM's.

(8) Malfunctions that normally could be corrected by use of an operator adjustment shall not be charged if acceptable operation can be resumed within 5 minutes by the operator.

(9) Automatic turn-off of the transmitter due to crowbarring, etc. if the transmitter comes back on after 3 or less attempts to reset. A failure will be charged if more than 8 transmitter turn-offs occur within 24 mission hours. During turn-on of the transmitter 3 attempts at starting are allowable.

NOTE: The transmitter shutdowns are primarily to protect the TWT from damage, and are a function of the particular TWT in the radar.

(10) Failure due to overstress conditions beyond those specified in the MN.

(11) Any phantom tripping of a circuit breaker will not be charged unless it exceeds two trips in 24 mission hours. One failure will be charged for each 24 mission hours in which any one circuit breaker trips

(12) Failures that are discovered during non-mission time, and either did not impact a mission, or would not have impacted a more stressing mission are not chargeable. (Only failures that occur during official mission time will be charged).

(13) Any malfunction that is charged against performance will not also be charged against reliability.

SECTION II

SCORING CRITERIA

Each chargeable failure as defined in SECTION I shall be scored against Mission Reliability (Rmis) in accordance with the following scoring criteria.

(1) Any failure that causes a mission abort (the test is stopped) or would cause the abort of a mission of a fielded system shall be charged against Rmis. (If a failure occurs during a particular mission that does not affect the success of the mission, but would affect a more stressing mission (still within spec) it will be charged).

(2) Failure of self-test circuitry that does not indicate a personnel safety or equipment hazard condition shall not be charged against Rmis.

(3) If a backup mode of operation can be utilized within 5 minutes by the operator or crew to complete the mission after a failure occurs, no charge will be made against Rmis.

(4) Failures of items that are redundant, and do not degrade performance to levels below those required by the MN shall not be charged against Rmis.

Redundant items in the radar include:

a) 64 phase shifters (61 of 64 required)
b) 64 phase shifter drivers (61 of 64 required)
c) 2 vertical channels of the B Scope (1 of 2 required)

SECTION III

RELIABILITY DETERMINATION

1. For the purpose of computing mission reliability the following will apply:

a. The total mission time will include the movement of the radar, emplacement, stand-by. operation, and displacement, of the radar. These times will be planned in advance and recorded by the test agencies.

b. If a failure occurs during the course of a prescribed mission the "clock" will stop until the system is returned to an operational state at which time the "clock" for computing mission time will again start. (An example is provided in Appendix B).

2. The mission reliability of both the radar and the total system will be calculated (Note: This will require that the test agencies determine the cause of failure of all GFE to determine the relevance of the failure, e.g. did a generator failure occur because of dirty fuel, improper preventive maintenance, etc..)

3. Reliability will be determined first by computing the mission MTBF. This will be the total number of mission hours divided by the total number of "mission-stopping" failures as defined in the above Failure Definition and Scoring Criteria.

SECTION IV

LOGISTICS IMPACT OF FAILURES

For the purpose of assessing the logistics impact of failures not chargeable against mission reliability, failures of the system that require unscheduled maintenance actions will be used to determine the mean time between unscheduled maintenance (MTBMu).

AMPLIFICATION:

1. Failures that require unscheduled maintenance resources will be used to determine (MTBMu).

2. Any failure chargable against mission reliability will be used to determine MTBMu..

3. The following will not be considered when computing MTBMu.

   a. Replacement of incidentals as previously described.

   b. Replacement or repairs of failed items done during scheduled maintenance time. (Bydefinition this cannot be unscheduled maintenance).

   c. Replacement of redundant circuitry replaced as a matter of convenience. E.g. if a failed phase shifter driver is replaced as a matter of convenience rather than necessity it will not be used when computing MTBMu.

   d. Maintenance required as a result of operator and/or technician errors or accidents.

   e. Minor repairs or adjustments requiring less than 5 minutes or done without impacting on a mission.

4. See Appendix C for examples.

APPENDIX 1

TERMS AND DEFINITIONS

1. Mission Reliability (Rmis)

a. The basic technical measurement will be mean-time between mission critical failures (MTBF mis).

b. A mission critical failure is any malfunction that will prevent an operationally ready item from accomplishing its primary mission.

c. Rmis is the basic expression of the radar's ability to perform its minimum essential functions for the duration of one specified mission given that it was operationally ready at the start of the mission.

d. Rmis will include only hours expended during the performance of a mission, as defined by a test plan prior to the mission, including transportation, emplacement, displacement, initialization, standby, radiate,

or any other mission oriented operation. Any failure that occurs at a time other than actual mission time cannot be charged against Rmis.

2. Repair - The replacement of a failed part/component with a new part/ component of the same design and rating to return the system to operation after a malfunction.

3. Corrective action - A change in system design to reduce the frequency of occurrence of a failure mode (This includes changes of a component's value, rating, etc.)

4. Mission time - The time that is expended during the performance of a mission, as defined by a test plan prior to the mission, including transportation, emplacement, displacement, initialization, standby, radiating, or any other mission oriented operation.

AN/TPQ-36

MORTAR LOCATING RADAR

MODERN AUTOMATED RADAR SYSTEM PROVIDES STRONG SUPPORT FOR THE FIELD ARMY

The automated AN/TPQ-36 Radar detects first-round mortar firings, automatically calculates their origin, and designates the weapon location accurately for counter-mortar fire. AN/TPQ-36 design is optimized for mortar location in co-deployment with the AN/TPQ-37 Artillery Locating Radar.

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GROUND SYSTEMS GROUP

MORTAR · ARTILLERY LOCATING RADARS
MALOR

The AN/TPQ-36 Mortar Locating Radar is being developed under direction of the Project Manager, Mortar and Artillery Locating Radars (MALOR), U.S. Army Electronics Command, Fort Monmouth, New Jersey. Contract No. DAAB07-74-C-0012.

APPENDIX D (

RESOLVING CURRENT PROBLEMS OF MORTAR LOCATION

With today's high firepower, hundreds of objects are in the air above a battlefield area at one time. The mission of counter-mortar radars is to identify incoming projectiles in this complex environment, and to locate the firing site. Existing manual radar systems cannot identify and cope with such a concentrated load; they are limited by the capacity of the operator. Even in a low intensity conflict, the operator usually requires more than one round to accurately locate the fleeting targets. When several weapons are firing simultaneously, the operator can handle only one target at a time.

TODAY'S PROBLEMS...AND THE AN/TPQ-36 SOLUTION

HIGH DENSITY VOLLEY FIRE . . . *Fast automatic detection of first round mortar firings, and simultaneous location of multiple weapons.*

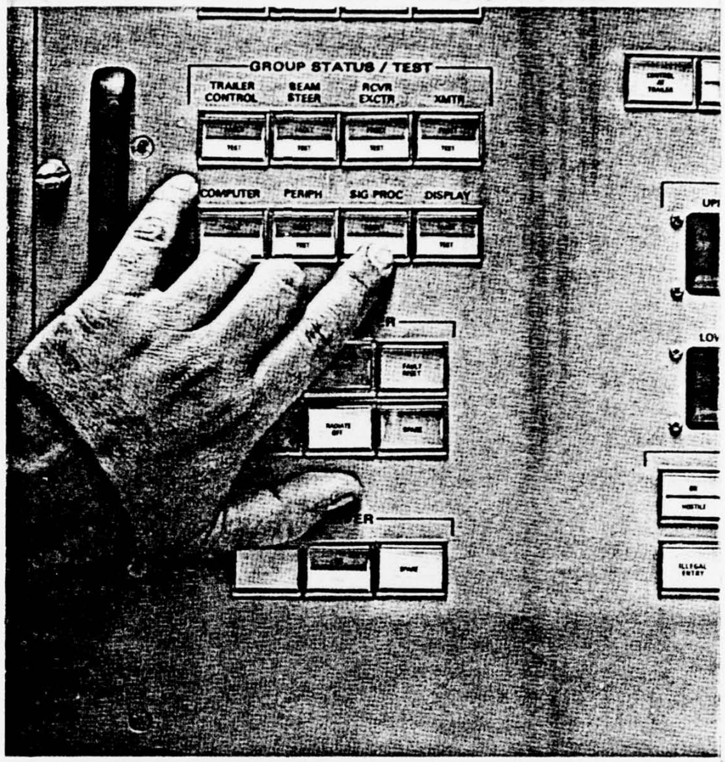
INTERFERENCE FROM CLUTTER AND JAMMING . . . *Excellent rejection of clutter, jamming and interference from other radars.*

SURVIVABILITY . . . *Self-contained modules provide mobility in fast moving battle, and are quickly set up in camouflage or revetment.*

APPENDIX D (Continued)

WORLD-WIDE OPERATION

Capability of the AN/TPQ-36 to operate effectively in all environmental extremes will be demonstrated by rigorous laboratory and mobility testing. The shelter can be conditioned to provide operator comfort in any locale.



Built-in test equipment facilitates maintenance by indicating fault location.

HIGH SYSTEM AVAILABILITY

Designed for simple field maintenance by enlisted organizational repairmen, the AN/TPQ-36 incorporates extensive built-in test equipment. Under computer control, the system performs self-diagnostics, fault detection and isolation. Use of proven reliable solid state components ensures high availability.

LOW PRODUCTION AND LIFE CYCLE COSTS

A rigorous design-to-cost engineering effort, plus low manning requirements for deployment, operation and maintenance, allow the AN/TPQ-36 to be purchased and owned at the lowest possible cost.

Live firing tests on the Engineering Development Models are scheduled for 1975, with production beginning in 1977.

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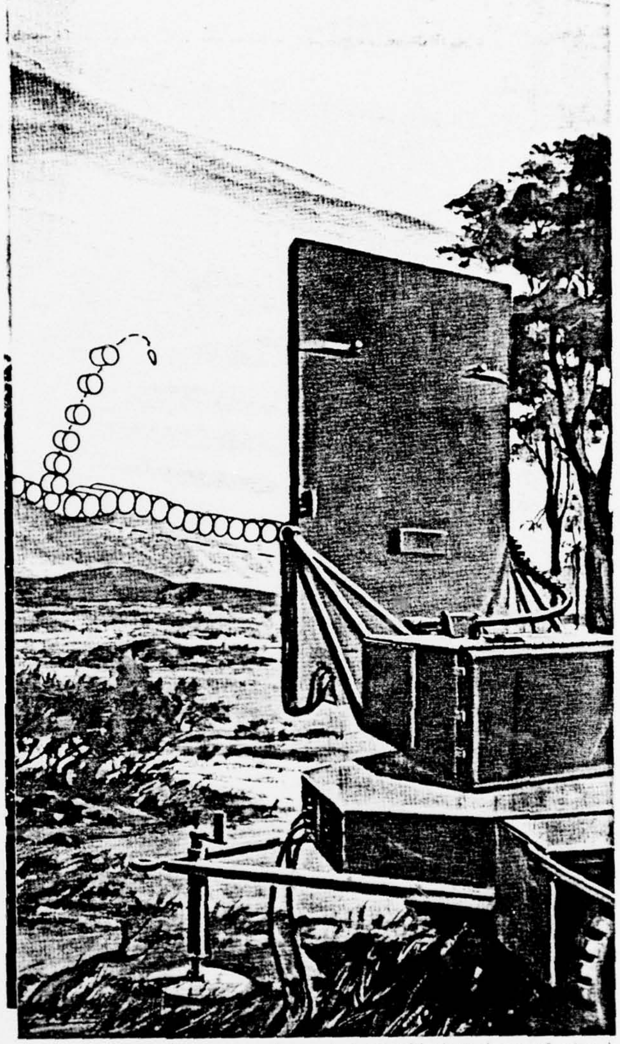
APPENDIX D (Continued)

AUTOMATED RESPONSE TO MORTAR FIRING



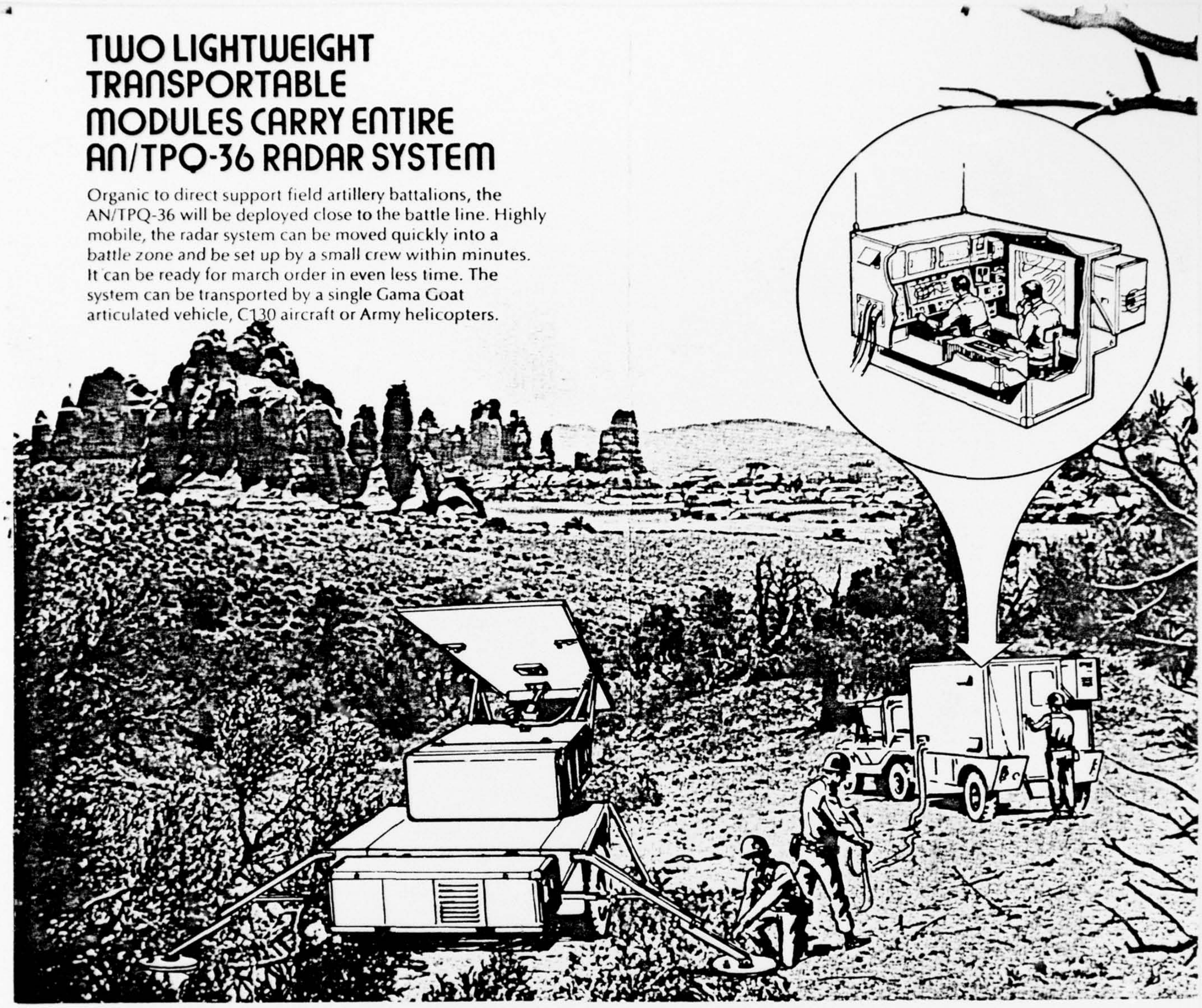
Continuous horizon scan forms electronic "blanket" above 90° azimuth sector to detect and automatically initiate tracking of mortar rounds

- Azimuth scan just above the horizon establishes an electronic screen over nearby enemy positions. Mortar firings are detected as they pass through the sensitive high-data-rate surveillance screen.
- The computer instantly directs the radar to point a verification beam at each target, then automatically initiates track.
- Filters in the signal and data processors reject returns from ground, weather, birds, insects and distant aircraft.
- While continuing the search program and tracking all verified targets, the computer "back tracks" each shell trajectory to its origin. Location data is displayed for the operator who transmits the target map coordinates to the artillery for effective counterfire.

APPENDIX D (Continued)

TWO LIGHTWEIGHT TRANSPORTABLE MODULES CARRY ENTIRE AN/TPQ-36 RADAR SYSTEM

Organic to direct support field artillery battalions, the AN/TPQ-36 will be deployed close to the battle line. Highly mobile, the radar system can be moved quickly into a battle zone and be set up by a small crew within minutes. It can be ready for march order in even less time. The system can be transported by a single Gama Goat articulated vehicle, C130 aircraft or Army helicopters.



***ANTENNA TRAILER** carries the antenna, beam steering computer, transmitter, some of the receiver stages and the prime power unit.*

***OPERATIONS SHELTER** contains all-digital signal processor, mini-computer, radar displays and controls, and communication facilities.*

Operator capacity is enhanced by the TPQ-36 automated aids and the efficient work station in the shelter. The operator sets operating criteria; in response the system can:

- Focus radar resources on small priority zones and reject fire from censor zones which contain friendly forces.
- Distinguish between projectiles on the basis of direction (toward or away from the radar), velocity, and acceleration.
- Detect a first-round firing, volley fire from a single fire unit or simultaneous firing from several units.
- Simultaneously search, verify returns and track valid targets, a flexibility inherent in inertialess beam steering.
- Automatically adapt radar performance to the density of the threat by increasing the selectivity of detection parameters as the number of targets increases.
- Discriminate between enemy weapons, giving priority to new weapons.
- Automatically display to the operator the highest priority weapon as a small spot of light on a rotating cylindrical map of the battle area on the Weapon Display Console.
- Simultaneously present the weapon position as a decimal display of site coordinates.

The operator's function is to quickly measure the site altitude from map contours, refine the computer trial location by correcting range error due to height differences, and transmit the coordinates to the Artillery Fire Direction Center. The computer immediately presents the next priority-ordered target with its site coordinates. With this sequence, many weapons can be handled quickly.

APPENDIX D (Continued)

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